National Park Service
U.S. Department of the Interior

Shenandoah National Park
Division of Natural & Cultural Resources
Branch of Natural Resources

Forest Health and Air Quality

Introduction

While documented negative effects of air pollutants on vegetation have existed for many years, it was thought that the effects of air pollution on vegetation were restricted to areas close to pollution sources (industrial areas and power plants) or to urban areas. Today we know the effects of air pollution extend to rural and even remote areas of the country. Unfortunately, some of those effects are seen in our National Parks.

The only major pollutant that appears not to adversely effect forest vegetation is carbon monoxide. Pollutants that do have an effect are referred to as phytotoxic.

Forest Health and Ozone

Ozone (O_3) is a gas composed of three oxygen atoms. The oxygen we need to live contains two oxygen atoms per molecule. A natural layer of ozone in the upper atmosphere is created by reactions of oxygen, nitrogen oxides, and ultra-violet radiation. Ozone has the same chemical structure whether it occurs miles above the earth or at ground level and can be "good" or "bad," depending on its location in the atmosphere. "Good" ozone occurs naturally in the stratosphere approximately 10 to 30 miles above the earth's surface and forms a layer that protects life on earth from the sun's harmful rays. In the earth's lower atmosphere, ground-level ozone is considered "bad."

Fuel combustion emits ozone but ozone also forms near the earth's surface when other chemicals in the air — nitrogen oxides and hydrocarbons — react in the presence of sunlight. Most nitrogen oxides and hydrocarbons come from car and truck exhaust. Ozone is the most wide-spread air pollutant in our country and is the main ingredient in smog.

Ground-level ozone interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, and harsh weather.

Plants that have been identified as reliable indicators of phytotoxic levels of pollutants are known as bioindicators. Examples of bioindicators for ozone include black cherry, blackberry, common milkweed and yellow-poplar. There are 40 ozone sensitive plants at Shenandoah.

Ozone damages the appearance of leaves on trees and other plants. The most common visible symptom of ozone injury on broad-leaved bioindicator species is uniform interveinal leaf stippling. As a gaseous pollutant, ozone enters the stomata of plant leaves through the normal process of gas exchange, damaging the tissue. Elevated levels of ozone have been documented at Shenandoah as has visible damage to Park vegetation. However, the effects of ozone on tree growth at Shenandoah is not particularly well understood.

Park staff members are concerned with this situation and therefore work on a variety of programs related to monitoring, research, and emissions reduction.

Forest Health and Acid Deposition

Scientists discovered, and have confirmed, that sulfur dioxide (SO_2) and nitrogen oxides (NOx) are the primary causes of acidic conditions in the atmosphere. In the United States, about 2/3 of all SO_2 and 1/4 of all NOx comes from electric power generation that relies on burning fossil fuels like coal.

Acidic conditions develop when these gases react in the atmosphere with water, oxygen, and other chemicals to form

various acidic compounds. Sunlight increases the rate of most of these reactions. The result is a mild solution of sulfuric acid and nitric acid. The acidic compounds then fall to or are deposited on the earth's surface.

Acid particles alter the nutrient and other chemical make-up of forest soils. This chemical alteration, may, at first, actually result in fertilization which may cause changes in plant growth, species composition, and pathogen development. Eventually the acidification results in impairment of plant growth and development because nutrients that would otherwise be available to be released and used by plants, are diminished. These chemical alterations are particularly acute at high elevation sites because nitrogen is limited in those soils to begin with. Nutrient deficiency can lead to susceptibility to disease.

Recent assessments of deposition and forest ecosystem circumstances at Shenandoah indicate that forest resources here are less susceptible to acid deposition. This is a result of various circumstances including comparatively lower levels of deposition, second growth conditions with higher demands for nitrogen, and lower cloud deposition rates. However, spruce-fir forests, which occur at high elevations and in limited locations in Shenandoah, are particularly sensitive to injury from acidification effects. Park soil conditions are not thoroughly understood but available information leads to the belief that certain areas may be more susceptible to adverse effect due to variable soil chemistry.

Forested areas within the Park are subjected to various forms of stress including drought, disease, and insect damage. In some cases, the diseases and insects are not native to the Park. Acid deposition builds on these conditions causing direct and indirect damage to forest vegetation.

Park staff members are working on this situation by monitoring acid deposition conditions, by supporting research to better understand the effects of deposition and predict the consequences, as well as by working on reducing emissions.